

The Distribution and Ecology of *Phyllitis scolopendrium* in Michigan

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The Hart's-tongue, *Phyllitis scolopendrium*, has been noted for its circumboreal and North American disjunct distributions (Fernald, 1935; Wagner, 1972). On this continent *P. scolopendrium* var. *americana* Fern. is known to occur in Ontario (Soper, 1954), Michigan (Hagenah, 1954, 1956), New York, Tennessee, and Alabama (Short, 1979). By far the majority of the Hart's-tongue sites are associated with the limestones and dolomites of the Niagara escarpment. This geological formation can be traced from central New York westward into Ontario, where it turns northwestward near the head of Lake Ontario, and through the Bruce Peninsula and Manitoulin Island in Lake Huron, into the upper peninsula of Michigan. From there it arcs southwestward through Wisconsin's Door Peninsula to the east of Green Bay and disappears to the south.

This paper will deal principally with the northernmost American Hart's-tongue colonies, those in upper Michigan, and with some ideas concerning the factors determining its distribution in that region.

A NEW LOCALITY IN MICHIGAN

On 3 August 1978, I discovered a previously unreported locality for *P. scolopendrium* in Mackinac County, Michigan, while I was botanizing along the slopes of a bedrock knob on the Niagara escarpment. The site is strewn with low, moss-covered dolomite boulders under a tree canopy almost completely dominated by *Acer saccharum*, with only minor numbers of other hardwood species (Fig. 1).

At the time of the discovery of the site, two fronds of *P. scolopendrium* were collected as a voucher specimen and deposited in the herbarium of the University of Michigan Biological Station (UMBS). Also found were *Polystichum lonchitis* and *Geranium robertianum* (Fig. 2), two plants frequently associated with *Phyllitis scolopendrium* (Hagenah, 1956). Walking Fern, *Camptosorus rhizophyllus*, occurs locally at the site, densely covering large boulders at least 1.5 m above the ground surface. Dr. W. H. Wagner, Jr. was among those visiting the site shortly after its discovery. He compiled the following list of pteridophytes on 29 August 1978: *Asplenium trichomanes*, *Botrychium virginianum*, *Camptosorus rhizophyllus*, *Cystopteris bulbifera*, *C. fragilis*, *Dryopteris filix-mas*, *D. intermedia*, *D. spinulosa*, *Equisetum arvense*, *E. scirpoides*, *E. sylvaticum*, *Matteuccia struthiopteris*, *Onoclea sensibilis*, *Polypodium virginianum*, *Polystichum braunii*, and *P. lonchitis*. All were found within 50 m of the *Phyllitis* colony. *Asplenium viride* also has been reported at the site (D. Henson, pers. comm.)

This new Hart's-tongue site is situated within the Hiawatha National Forest, and will be referred to here as the "East Lake station." In the Fall of 1978, the U.S. Forest Service decided to survey and map the extent of the *Phyllitis* colony.

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FIG. 1. General view of part of the East Lake station of *Phyllitis scolopendrium*, Mackinac Co., Michigan. A group of the ferns is growing on the side of the boulder in the central foreground. The map tube (horizontal) in the right foreground is 65 cm long. FIG. 2. *Phyllitis scolopendrium* growing on a low boulder, along with *Polystichum lonchitis* and *Geranium robertianum* on top of boulder.

In all, 64 individuals were counted, their locations mapped, and the tree nearest to each group of individuals was marked. In combination with long-term observation, this information has potential for use in studying the population ecology of this rare fern.

During the summer of 1979, the U.S. Forest Service undertook an inventory of all prospective localities within the borders of the Hiawatha National Forest in hopes of uncovering other unreported Hart's-tongue sites. Unfortunately, no success was reported.

DISTRIBUTION IN UPPER MICHIGAN

Hagenah (1954, 1956) reported on the first two upper Michigan sites for *P. scolopendrium*. The East Lake station is situated between these two, which are 30 km. apart (Fig. 3). The population at the Trout Lake station in Chippewa County apparently is extinct. The easternmost station, known as the Hagenah site, has recently been acquired by the Michigan Nature Association as a plant preserve. The location of these sites and the major North American concentration of *P. scolopendrium* in Ontario, south of Lake Huron, are shown in Figure 3.

All three Michigan localities are similarly located on prominent hills that are part of the Niagara escarpment. Along much of its length in Mackinac and Chippewa counties, the escarpment is obscured by thick deposits of glacial drift. The position of the escarpment is manifested mainly by a series of bedrock knobs scattered from east to west across the region. These hills rise 30–100 m above the surrounding plain and range in area from 150 to over 3000 hectares. It is highly unlikely that they were ice-free nunataks during the Wisconsin glacialiation, as suggested by Fernald (1935) in explaining the occurrence of Hart's-tongue on the highest outcrops of the same escarpment in Ontario.

Another similarity shared by the three localities is that the Hart's-tongue colonies are situated at elevations near or above that of the ancient shoreline of Lake Algonquin. In fact, the East Lake station was discovered in the course of floristic reconnaissance along one such shoreline. The plants are growing on boulders uncovered by wave action. Lake Algonquin, a precursor of lakes Huron and Michigan, covered much of upper Michigan immediately upon retreat of the continental ice sheet about 11,000 years ago. At that time the bedrock hills that define the Niagara escarpment formed an archipelago in the lake. By about 10,400 years ago Lake Algonquin ended when the waters fell to lower levels and more of the present land area was uncovered.

The fact that *P. scolopendrium* has been found in upper Michigan only in places that were islands in Lake Algonquin may have some special significance. Throughout Mackinac and parts of Chippewa counties, there is a large area which was inundated by Lake Algonquin but now is covered by deciduous forests of the sort preferred by the fern, in which there are limestone and dolomite outcrops (e.g., Drummond Island) or concentrations of glacially-transported boulders. Although actively sought, Hart's-tongue has not been seen in those places. This distribution pattern may be explained in several ways; here we will consider three hypotheses.

Hypothesis 1.—*Phyllitis scolopendrium* was dispersed to upper Michigan, presumably from the south, at the time of the existence of Lake Algonquin, ca. 10,500 years ago. These rocky islands with their depauperate flora may have offered suitable substrates and conditions of low competition favorable to the establish-

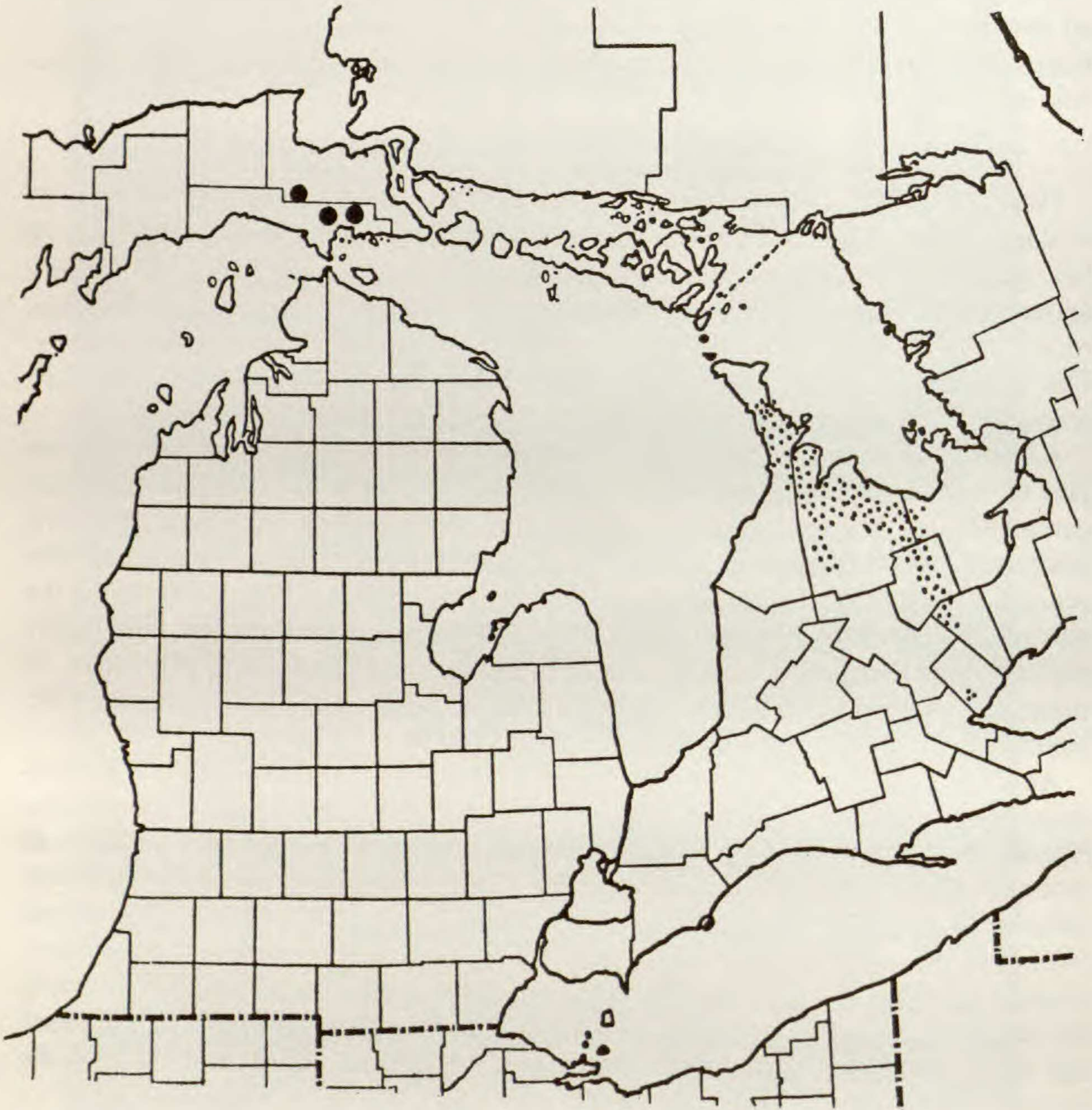


FIG. 3. Distribution of *Phyllitis scolopendrium* in the upper Great Lakes region. The three stations of the fern in upper Michigan are indicated by dots. The general area where the fern occurs in Ontario is shown by stippling. (modified from Soper, 1954).

ment of this fern. When more land area was uncovered by the recession of lake levels and closed forests covered the region, *P. scolopendrium* may not have been a sufficiently aggressive colonizer to spread from its territory acquired earlier.

Hypothesis 2.—Confinement of *P. scolopendrium* to the former islands may be a result of environmental differences between hilltop rock outcrops and those at

lower elevations. The hills along the escarpment have thin soils with more outcrops, and the fact that they were high enough to escape submergence under Lake Algonquin may be only a coincidence. Fewer favorable sites for the fern exist at lower elevations because thicker deposits of glacial till and lake sediments cover the bedrock. At those lowland sites where rock surfaces are available, other environmental factors may be unfavorable.

Hypothesis 3.—*P. scolopendrium* had (or has) a wider distribution in upper Michigan than is known at present. Logging of forests may have opened the vegetation at many former localities of the fern, making the sites unsuitable and leading to its extinction. Therefore, the original distribution of the Hart's-tongue in upper Michigan prior to European settlement had little to do with the geography of Lake Algonquin.

DISCUSSION

The suggestion that *P. scolopendrium* first reached upper Michigan during the existence of Lake Algonquin has some appeal. Such an hypothesis could explain why extensive areas of limestone outcrops which are situated between the Michigan stations and the main North American concentration of Hart's-tongue in Ontario, and which were inundated by Lake Algonquin, such as Manitoulin Island and Drummond Island, are devoid of the fern. The Bruce Peninsula, where many of the Ontario stations are located, also was completely submerged at that time, but one may propose that its connection to the mainland at a point where many non-submerged Hart's-tongue localities exist facilitated its colonization at a later date.

However, fossil pollen studies by the present author and others (Brubaker, 1975; Saarnisto, 1974) indicate that the late-glacial forests of the region, during and after the existence of Lake Algonquin, comprised mainly spruce (*Picea* spp.) and jack pine (*Pinus banksiana*). A salient feature of the ecology of *Phyllitis scolopendrium* var. *americana* is that it is never found in coniferous forests, even when adjacent tracts of deciduous forests contain the fern. In Ontario it is seen under deciduous canopies ranging from successional poplar stands to climax maple-beech forest, but never under conifers (A. Reznicek, pers. comm.). If the Hart's-tongue is a strict associate of the northern hardwoods forest, then it might have reached northern Michigan only within the past 5000 years, which is when this vegetation type became most widespread in the region. Thus, unless the ecology of this species was different 10,500 years ago from what it is today, we should be safe in rejecting the first hypothesis.

The effect of forest clearance on populations of *P. scolopendrium* is poorly known. Most of the localities in Ontario and Michigan have been logged at one time or another. In the case of the East Lake station, logging did take place, but perhaps not to the extent of clearcutting. The example of the Ontario Hart's-tongue colonies found in early successional *Populus* woods shows that it can be an aggressive colonizer little affected by logging, provided that spore sources exist nearby. There is still the possibility that small, isolated colonies could become extinct and not be recolonized after logging and forest regrowth.

Most North American *P. scolopendrium* sites appear to be associated with moist slopes or hillsides, such as bouldery talus slopes and crests of escarpments (Soper, 1954) and sinkholes (Short, 1979). Along the Michigan outcrops of the Niagara escarpment, there are very few places where there is a high, steep cliff below which a rocky talus has accumulated. The Michigan Hart's-tongue colonies are found where bedrock just breaks through the surface on a moderately steep hillside or on slopes with a high concentration of low boulders that are separate from the bedrock. At the East Lake station, and possibly the second, easternmost locality described by Hagenah (1956), the boulders on which the ferns are growing represent a lag deposit formed by the removal of the surrounding sandy till by the action of the waters of Lake Algonquin. The boulders themselves had been quarried from nearby outcrops by the glacier and carried only a short distance before being deposited.

Extensive flat areas with limestone bedrock near or outcropping at the surface, such as Manitoulin and Drummond islands, do not appear to be suitable. Possibly these present too dry a habitat (Hagenah, 1956) or the forests are too open for the Hart's-tongue.

Another indicator of this fern's requirement for moist conditions is its preference for growing on low boulders no more than 30 or 40 cm above the forest leaf litter (Fig. 2) or in crevices of limestone pavement. The plants would be more exposed and subject to desiccation on sheer cliff faces or higher on boulders. Low position may also be a consequence of insulation and protection from desiccation provided by winter snow at northern localities.

Large, glacially transported dolomite and limestone boulders exposed above the soil are scattered throughout much of Mackinac County south of the Niagara escarpment. Most are close to 1 m in diameter, but individuals 2–3 m in diameter are not unusual. Seldom do these boulders occur in concentrations similar to those seen in typical Hart's-tongue habitat. Although the overall forest setting may seem suitable, these boulders may present desiccation problems and may be too few at any given location to provide a sufficient number of microsites for a viable colony of *P. scolopendrium* to become established.

CONCLUSIONS

Phyllitis scolopendrium has now been reported from three localities on the Niagara escarpment in upper Michigan. All three stations are similar in that they are situated on hills that were islands in Lake Algonquin, which existed ca. 10,500 years ago. Despite assiduous searching by botanists, *P. scolopendrium* has never been found in this region on ground that had been inundated by Lake Algonquin.

This interesting distribution pattern probably does not indicate that *P. scolopendrium* first reached these sites while Lake Algonquin was in existence, for the late-glacial vegetation was coniferous forest, a vegetation type at present not associated with this fern. A more likely explanation is that these hillside sites fulfill the fern's environmental requirements in terms of topography, moisture, and microsite abundance more adequately than other sites where limestone outcrops and boulders are available.

We can never be certain that *P. scolopendrium* did not occur in a greater number of localities in upper Michigan at some time in the last 10,000 years. More intensive botanical exploration in the region may eventually confirm or refute the apparent correspondence between Hart's-tongue fern localities and island areas in Lake Algonquin. In this regard it may be productive to pay particular attention to boulder concentrations along the ancient shorelines of this glacial lake.

With respect to determining the time of immigration of *P. scolopendrium* to upper Michigan, we can only say that it arrived less than 10,000 years ago and possibly only within the last 5000 years. There is little hope of being able to pinpoint this date more exactly, for it is unlikely that the spores or other parts of this rare plant will be found in the fossil condition.

Therefore, the first hypothesis is the least likely and the second is the most plausible explanation for the distribution of Hart's-tongue in Michigan. We do not have sufficient information to reject the third hypothesis.

In order to understand the factors determining the geographic distribution of rare plant species such as *P. scolopendrium*, we must take into account the vegetational history of the region, as well as the ecological relationships between rare species and the biotic and abiotic components of their immediate environment. Further contributions in this regard can be made by studying the population dynamics of known colonies of *P. scolopendrium*. Such a study will be possible at the East Lake station, where an entire Hart's-tongue colony has been counted and mapped.

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LITERATURE CITED

- BRUBAKER, L. B. 1975. Postglacial forest patterns associated with till and outwash in northcentral upper Michigan. *Quaternary Res.* 5:499-527.
- FERNALD, M. L. 1935. Critical plants of the Upper Great Lakes region of Ontario and Michigan. *Rhodora* 37:197-222, 238-262, 272-301, 324-341.
- HAGENAH, D. J. 1954. The Hart's-tongue in Michigan. *Amer. Fern J.* 44:2-7.
- . 1956. More Hart's-tongue in Michigan. *Amer. Fern J.* 46:70-74.
- SAARNISTO, M. 1974. The deglaciation history of the Lake Superior region and its climatic implications. *Quaternary Res.* 4:316-339.
- SHORT, J. W. 1979. *Phyllitis scolopendrium* newly discovered in Alabama. *Amer. Fern J.* 69:47-48.
- SOPER, J. H. 1954. The Hart's-tongue fern in Ontario. *Amer. Fern J.* 44:129-147.
- WAGNER, W. H., Jr. 1972. Disjunctions in homosporous vascular plants. *Ann. Missouri Bot. Gard.* 59:203-217.